Discrete bottle data from Hydrostation S in the Sargasso Sea from January 1955 through June 2025

Website: https://www.bco-dmo.org/dataset/859990
Data Type: Cruise Results
Version: 7
Version Date: 2026-01-13

Project
» The Panulirus Hydrographic Stations (Hydrostation S) (Hydrostation S)

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Abstract
Data presented here are discrete bottle samples from the Hydrostation S (or Panulirus) time series site located 20 km SE of Bermuda (32°10’N, 64°30’W) in the Sargasso Sea for January 1955 (cruise #60009) through June 2025 (cruise #61501). Measurements were collected at near biweekly intervals where possible depending on weather and ship availability. Prior to the arrival of Weatherbird I in 1983, station occupation during winter months was limited due to the sea-going capabilities of the former vessels. The standard sample parameter list has been mostly consistent for the full time-series record and includes temperature, salinity, and dissolved oxygen. Since October 1988 (cruise #60643), data and samples have been collected using a SeaBird 911+ CTD and integrated Niskin rosette system. The largest data gap of almost one year was due to the loss of all the Niskin bottles and reversing thermometers following a break in the hydro wire on station #463 (April 1979).

Table of Contents

- Coverage
- Dataset Description
  - Methods & Sampling
  - Data Processing Description
  - BCO-DMO Processing Description
  - Problem Description
- Data Files
- Supplemental Files
- Related Publications
- Parameters
- Instruments
- Deployments
- Project Information
- Funding

Coverage

Location: Hydrostation S located 25 km SE of Bermuda (32°10' N, 64°30' W)
Spatial Extent: **N**:32.983 **E**:-63.289 **S**:30.154 **W**:-66.799
Temporal Extent: 1955-01-29 - 2025-06-19

Dataset Description

Hydrographic measurements from discrete water bottle samples collected at Hydrostation S located 25 km SE of Bermuda (32°10' N, 64°30' W). Measurements have been collected since 1954 at the Panulirus hydrographic stations and include salinity, temperature, sigma theta, and dissolved oxygen.

Methods & Sampling

The data presented here are discrete bottle samples from the Hydrostation S (or Panulirus) time series site from January 1955 (cruise #60009) through June 2025 (cruise #61501)

Water samples have been collected at the Panulirus site, located about 25 kilometers southeast of Bermuda, since 1954 when Henry 'Hank' Stommel and co-workers initiated repeat biweekly hydrographic measurements and observations.

The bottle samples were originally collected from Hydrocasts using Niskin bottles and reversing thermometers for temperature and thermometric depth. CTD profiling was introduced to the Panulirus project in October 1988 and the methodology used for collection of CTD data and integrated water samples has been consistent with those used on the Bermuda Atlantic Time series Study (see Knap et al., 1997). The standard sample parameter list has been mostly consistent for the full time-series record and includes temperature, salinity, and dissolved oxygen. Since October 1988 (cruise #60643), data and samples have been collected using a SeaBird 911+ CTD and an integrated Niskin rosette system. The largest data gap of almost one year was due to the loss of all the Niskin bottles and reversing thermometers following a break in the hydro wire on station #463 (April 1979).

Further information on the data collection from 1954-1984 can be obtained in the Joint WHOI and BBSR (BIOS) data report 'Station S off Bermuda, Physical measurements 1954-1988 (WHOI contribution No. 6894)' by Metcalf et al. (1988).

Ship information:
- R/V Panulirus I (June 1954-May 1967)
- R/V Panulirus II (June 1967-December 1982)
- R/V Weatherbird I (January 1983 - September 1989)
- R/V Weatherbird II (October 1989 - April 2006)
- R/V Atlantic Explorer (May 2006 - November 2024)
- R/V Endeavor (December 2024)
- R/V Neil Armstrong (January - February 2025)
- R/V Atlantic Explorer (March - June 2025)

Numerous Chief Scientists have carried out the sampling during the cruises:
William Sutcliffe, David Menzel, John Beers, Albert Brooks, Fred Mackenzie, Roger Pocklington, Eric Amos, Byron Morris, John Barnes, Anthony (Tony) Knap, Timothy Jickells, Rachel Sheriff-Dow, Anthony Michaels, Kjell Gundersen, Rodney Johnson, Ann Close, Paul Lethaby, Julian Mitchell, Vivienne Lochhead, Deborah Lomas, Steven Bell, Jonathan Whitefield, Gwyn Evans, James Sadler, Samuel Monk, Samuel Stevens, Afonso Goncalves, Matt Enright, Fernando Pacheco, Zac Anderson, Claire Medley, Dominic Smith, Rebecca May and Lucinda Derbyshire.

Data Processing Description

Data was processed, evaluated, and flagged using the following Quality Flag definitions:

* Bottle (Niskin or Go-Flo) quality flags: -3= suspect, 1= unverified, 2= verified/acceptable
* Parameter data quality flags: 1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data

Note: Previous version(s) had Oxygen Fix Temperature (OxFix) and Oxygen Anomaly (Anom1). For v005 onward, it was deemed not necessary to include the oxygen fix temperature since it was specific to BIOS internal use. Oxygen anomaly was removed since it is a calculated variable.

BCO-DMO Processing Description

** Version 7 (v007) **
This version adds data from new cruises 61491-61501 (January-June 2025) to existing data beginning in 1955 (cruises 60009 through 61490).
Imported data from files “hydrostation_bottle_qcmask_v007.txt" and “hydrostation_bottle_v007.txt” into the BCO-DMO data system. Data files imported using missing data identifiers (nd, -999, -999.0, -999.000).
a) Joined the two files using join keys of Id, yyyymmdd, latN, and lonW
b) Modified parameter names to conform with BCO-DMO naming conventions
c) Converted latitude and longitude values to decimal degrees
d) Zero-padded the values in the time column and combined with the date column to create a new ISO 8601 DateTime field.
e) Using information from the Bottle_ID column, created columns for Cruise, Cast, and Bottle
f) Added a field for Vessel
g) Renamed the quality flag fields to have the measurement description (rather than QF1, QF2, etc) and moved flags adjacent to the corresponding measurement columns.
Exported file as "859990_v7_hydrostation_s_bottle.csv"

** Version 6 (v006) **
This version adds data from July 16th, 2024 through December 2024 (new cruises 61479-61490) to the existing data from 1955 onward (cruises 60009 to 61478).
Imported data from files “hydrostation_bottle_qcmask_v006.txt" and “hydrostation_bottle_v006.txt” into the BCO-DMO data system. Data files imported using missing data identifiers (nd, -999, -999.0, -999.000).
- Completed steps a) through g) as listed above
Exported file as "859990_v6_hydrostation_s_bottle.csv"

** Version 5 (v005) **
This version adds data from January 2024 through July 2024 (new cruises 61466-61478) to the existing data from 1955 onward (cruises 60009 to 61465)
Imported data from files "hydrostation_bottle_qcmask_v005.txt" and "hydrostation_bottle_v005.txt" into the BCO-DMO data system. Data files imported using missing data identifiers (nd, -999, -999.0, -999.000).
- Completed steps a) through g) as listed above
Exported combined file as "859990_v5_hydrostation_s_bottle.csv"

** Version 4 (v004) **
This was the first archival version of the Hydrostation S bottle data. Previous versions were made publicly available on the BCO-DMO site, but did not have any DOI's minted for them. Those prior versions were superseded by this version. The DOI version matches the Bermuda Atlantic TimeSeries data versions.
Imported data from files “hydrostation_bottle_qcmask_v004.txt" and “hydrostation_bottle_v004” into the BCO-DMO data system. Data file imported using missing data identifiers (nd, -999, -999.0, -999.000).
- Completed steps a) through g) as listed above
Exported file as "859990_v4_hydrostation_s_bottle.csv"

** See the attached release notes for more information. **

Problem Description

In April 1979, there was a break in the hydro wire on station #463, resulting in the loss of all the Niskin bottles and reversing thermometers.

Prior to the arrival of the vessel Weatherbird I in 1983, station occupation during winter months was limited

due to the sea-going capabilities of the former vessels.

[table of contents | back to top]

Data Files

File	
859990_v7_hydrostation_s_bottle.csv	(Comma Separated Values (.csv), 5.69 MB) MD5:942e8cfe1473fd5a31ca593035f7418b
Hydrostation S bottle data for January 1955 through June 2025; Primary data file for dataset ID 859990, version 7	

[table of contents | back to top]

Supplemental Files

File	
Hydrostation S bottle data version 007 update file filename: hydro_bottle_release_v007_update.txt	(Plain Text, 461 bytes) MD5:7917f35af37d37affed06a8cd3ae6be0
ASCII file listing changes/new cruises in current version (v007) of Hydrostation S bottle data and differences from previous versions.	

[table of contents | back to top]

Related Publications

Bermuda Atlantic Time-series Study Methods (online at https://bats.bios.edu/about/cruise-information/)
Methods

Jenkins, W. J. (1982). On the climate of a subtropical ocean gyre: Decade timescale variations in water mass renewal in the Sargasso Sea. Journal of Marine Research, 40 (Supp.), 265-290.
Methods

Knap, A.H., Michaels, A.F., Steinberg, D.K., Bahr, F., Bates, N.R., Bell, S., Countway, P., Close, A.R., Doyle, A.P., Dow, R.L., Howse, F.A., Gundersen, K., Johnson, R.J., Kelly, R., Little, R., Orcutt, K., Parsons, R., Rathburn, C., Sanderson, M. and Stone, S. (1997) BATS Methods Manual, Version 4 Woods Hole, MA, US. U.S. JGOFS Planning Office 136pp. http://eprints.soton.ac.uk/id/eprint/361194
Methods

Metcalf, W.G., Stommel, H., Wright, W.R., Sherriff-Dow, R., Knapp, G., and Stanley, R. (1988) Station “S” off Bermuda: physical measurements, 1954-1984. Woods Hole Oceanographic Institution contribution No. 6894.
Related Research

[table of contents | back to top]

Parameters

Parameter	Description	Units
ISO_DateTime_UTC	Date and Time in ISO8601 standard format	unitless
decimal_year	Decimal year	dimensionless

Bottle_ID	Unique bottle ID which identifies cruise type, cruise, cast, and Niskin bottle number	unitless
Latitude	Latitude	decimal degrees
Longitude	Longitude (West is negative)	decimal degrees
Vessel	Research vessel used for sampling	unitless
Cruise_num	Cruise number	unitless
Cast_num	Cast number; 1-80=CTD casts, 81-99=Hydrocasts (i.e. 83 = Data from Hydrocast number 3	unitless
Bottle_num	Bottle number of sample	unitless
QF_Bottle	Quality flag for Niskin or Go-Flo bottles (-3 = suspect, 1=unverified, 2= verified/acceptable)	unitless
Depth	Depth	meters (m)
QF_Depth	Quality flag for depth (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
CTD_Pressure	CTD pressure	dbar
QF_CTD_press	Quality flag for CTD pressure (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
Temperature	Temperature in ITS-90 standard	degrees Celsius (°C)
QF_Temp	Quality flag for Temperature (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
CTD_Salinity	CTD Salinity on PSS-78 scale	dimensionless
QF_CTD_Sal	Quality flag for CTD salinity (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
Salinity_1	Salinity-1 measurement on PSS-78 scale	dimensionless

QF_Salinity	Quality flag for Salinity-1 (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
Sigma_theta	Sigma-theta measurement	kilograms per cubic meter (kg/m^3)
QF_Sigma_theta	Quality flag for sigma-theta measurement (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
Oxygen	Oxygen-1	micromoles per kilogram (umol/kg)
QF_Oxygen	Quality flag for Oxygen-1 measurement (1= unverified, 2= verified acceptable, 3= questionable, 4= bad, 9= no data)	unitless
yyyymmdd	Date	unitless
time	Time	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	CTD Sea-Bird 911
Generic Instrument Name	CTD Sea-Bird 911
Generic Instrument Description	The Sea-Bird SBE 911 is a type of CTD instrument package. The SBE 911 includes the SBE 9 Underwater Unit and the SBE 11 Deck Unit (for real-time readout using conductive wire) for deployment from a vessel. The combination of the SBE 9 and SBE 11 is called a SBE 911. The SBE 9 uses Sea-Bird's standard modular temperature and conductivity sensors (SBE 3 and SBE 4). The SBE 9 CTD can be configured with auxiliary sensors to measure other parameters including dissolved oxygen, pH, turbidity, fluorescence, light (PAR), light transmission, etc.). More information from Sea-Bird Electronics.

Dataset-specific Instrument Name	Go-FLo bottle
Generic Instrument Name	GO-FLO Bottle
Dataset-specific Description	Go-Flo bottles are made by General Oceanics, and they allow water to flow through them once past the initial top layer of water, and up until they are triggered to close. The tubes are made of stout PVC that can be sent to depths of 500m or more.
Generic Instrument Description	GO-FLO bottle cast used to collect water samples for pigment, nutrient, plankton, etc. The GO-FLO sampling bottle is specially designed to avoid sample contamination at the surface, internal spring contamination, loss of sample on deck (internal seals), and exchange of water from different depths.

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	Guildline salinometer
Generic Instrument Name	Salinometer
Generic Instrument Description	A salinometer is a device designed to measure the salinity, or dissolved salt content, of a solution.

[table of contents | back to top]

Deployments

BATS_cruises

Website	https://www.bco-dmo.org/deployment/58883
Platform	Multiple Vessels
Report	http://bats.bios.edu/bats-data/
Start Date	1988-10-20
Description	Bermuda Institute of Ocean Science established the Bermuda Atlantic Time-series Study with the objective of acquiring diverse and detailed time-series data. BATS makes monthly measurements of important hydrographic, biological and chemical parameters throughout the water column at the BATS Study Site, located at 31 40N, 64 10W.

Panulirus_site_cruises

Website	https://www.bco-dmo.org/deployment/936706
Platform	Multiple Vessels
Start Date	1988-10-26
Description	Hydrostation S (formerly known as the Panulirus hydrographic station) is recognized as one of the most important sustained ocean time-series sites in the world. Located about 25 km southeast of Bermuda in the North Atlantic Ocean, this site has oceanographic measurements dating back to 1954, when Henry Stommel and co-workers initiated repeat biweekly hydrographic observations.

[table of contents | back to top]

Project Information

The Panulirus Hydrographic Stations (Hydrostation S) (Hydrostation S)

Website: http://www.bios.edu/research/projects/hydrostation-s/

Coverage: Sargasso Sea at 31 50'N 64 10'W

Hydrostation S (also known as Panulirus hydrographic station) is recognized as one of the most important sustained ocean time-series sites in the world. Located about 25 km southeast of Bermuda in the North Atlantic Ocean, this site has oceanographic measurements dating back to 1954, when Henry Stommel and co-workers initiated repeat biweekly hydrographic observations.

The most recent project awards and abstracts are listed below. A detailed **history of funding** with summary of all project awards for Hydrostation S (Panulirus Hydrographic stations) can be found here (PDF format): https://datadocs.bco-dmo.org/docs/305/Hydrostation_S/data_docs/Hydrostation_S_funding_history.pdf

Years 70-74:
NSF Award OCE-2122606 Abstract:

This project continues hydrographic observations at Hydrostation S, extending the time-series of ocean data to almost 70 years. Hydrostation S (formerly known as the Panulirus site), located about 25 km southeast of Bermuda in the North Atlantic Ocean, is one of the longest open-ocean hydrographic stations in the world. This program of repeat biweekly hydrographic observations began in 1954 and now, in its seventh decade, has proved to be the catalyst for numerous studies of ocean physics, biological processes and biogeochemistry. Sustained observations of the ocean, such as those from Hydrostation S, remain critically important to establish rates of change to provide quantitative empirical data for myriad regional and global ocean synthesis and modeling of ocean processes and future ocean change. Hydrostation S program and its data are considered as a service to the community, being openly distributed and subsequently have been an invaluable resource in understanding processes and patterns of variability in the ocean, as well as education, mentorship and outreach activities.

The major objective of the proposal is to continue Hydrostation S into the eighth decade with numerous questions related to warming and cooling, salinification and freshening, deoxygenation and insights on biogeochemical changes over time. This program constitutes frequent water column sampling of temperature, salinity, and dissolved oxygen (and indirectly, sampling of important ocean carbon time–series) of the North Atlantic subtropical gyre at the Hydrostation S site. Such work is complementary to other sustained observations such as the Bermuda Atlantic Time–series Study (BATS) and Ocean Flux Program (OFP). The project entails a similar sampling format that has been followed for the past 68 years. Hydrostation S also supports the longest global ocean CO2 and acidification time-series (from 1983 to present).

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Years 65-69:

NSF Award OCE-1633125 Abstract:
The physical properties of the ocean from the surface layers to the abyssal water masses are changing in concert with natural and anthropogenically influenced physical forcing and sustained observations of the ocean are critically important to establish these rates of change. One of the longest open-ocean hydrographic stations in the world is maintained at the Hydrostation S site (formerly known as the Panulirus site) located about 25 km southeast of Bermuda in the North Atlantic Ocean. This repeat biweekly hydrographic observations was initiated by Henry Stommel and co-workers in 1954. Now, in its seventh decade, it continues to be recognized as one of the most important sustained ocean time-series and provides an invaluable metric for the long-term state of the North Atlantic subtropical gyre in relation to the meridional overturning circulation, western boundary transport, and gyre recirculation. For example, the upper ocean warming trend has strengthened (about 0.8° C since the 1970's) while the deep Labrador Sea has cooled by a few tenths of a degree. The signature of deoxygenation has been observed at Hydrostation S in the upper ocean (about 7 micro-moles/kg/decade decrease in dissolved oxygen) as well as an intensification and expansion of the oxygen minimum zone. These changes suggest that the North Atlantic subtropical gyre is experiencing deoxygenation as in the Pacific Ocean as a result of increased upper ocean stratification and reduced solubility of oxygen in warmer waters. The Hydrostation S program and its data set are managed as a service to the ocean community, being openly distributed and used as a resource in understanding processes and patterns of variability in the ocean, as well as for education, mentorship and outreach activities. The Hydrostation S project will contribute to the research and training of six research specialists and research technicians at BIOS and contribute to the research projects of at least three Ph.D. students through on-going educational partnership with Princeton University and the University of Southampton in the U.K. The one-day Hydrostation S research cruises are an ideal platform for testing new sensors and for providing hand-on training to undergraduate students enrolled in summer programs.

The Hydrostation S project is designed to address the overarching hypothesis that the physical properties of the upper-ocean to deep-ocean are changing in concert with natural and anthropogenically influenced physical forcing. Sustained observations of the ocean, such as those from Hydrostation S, remain critically important to establish rates of change to provide quantitative empirical data for myriad regional and global ocean synthesis and modeling of ocean processes and future ocean change. The major objective of Hydrostation S into the seventh decade is to continue the frequent water column sampling of temperature, salinity, and dissolved oxygen (and indirectly, sampling of important ocean carbon time?series) of the North Atlantic subtropical gyre. Such work is complementary to other sustained observations such as the Bermuda Atlantic Time-series Study (BATS) and Ocean Flux Program (OFP). As for the past five years, two CTD profiles will be conducted to better capture the deep-water variability while maintaining all the previous discrete depths. The first CTD cast will profile to full ocean depth (3,200-3,500 m) while the second CTD cast will profile from the surface to 500 m to allow for biogeochemical instrumentation not rated for full ocean depth and to support ancillary studies of ocean physics, biological processes and biogeochemistry. A secondary objective will be to build upon the collaborative comparison of physical data collected as part of two autonomous sensor projects. In the latter stages of the project, as ocean glider deployment becomes more sustainable and reliable, collaborative and comparative efforts will be used to test the capability of ocean gliders to provide data of sufficient quality to detect long-term oceanic change in a "virtual" mooring time-series mode. The robust and highly accurate Hydrostation S data will be used to test the capability of emerging technologies over the next five to ten years.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1633125
NSF Division of Ocean Sciences (NSF OCE)	OCE-2122606

[table of contents | back to top]